



**Cummins Westport Inc.**

## **Natural Gas Engines in Your Future?**

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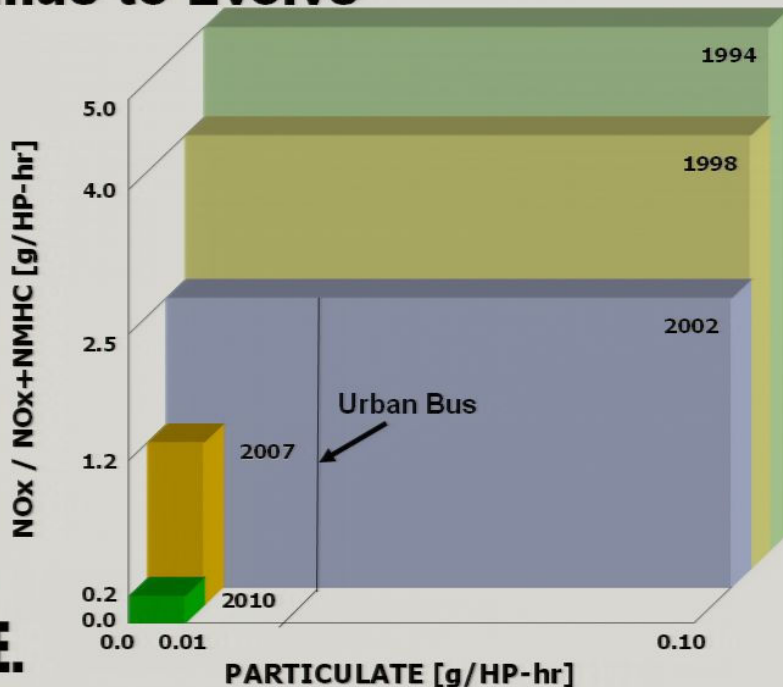
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TIME.**



# U.S. Emissions Standards Continue to Evolve



500 PPM

SULFUR

15 PPM

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## **Diesel versus Natural Gas - 2007**

### **ULSD**

- New Infrastructure Requirements
  - Changes with pre '07 engines
  - Added cost
- Lube Oil
  - Will require new, possibly more expensive oil
- Different oil filters
  - Will require new, possibly more expensive filters
- Crank Case ventilation absorbed in '07
  - Sensor impact
- Diesel Particulate Trap
  - Added cost
  - Additional maintenance cost

### **Natural Gas**

- Same infrastructure
  - Will be consistent for all gas engines
- Lube oil
  - Low ash, already in place
- Oil Filters-
  - Already in place & proven
- Crank Case ventilation-
  - Already in place and proven
- Oxidation Catalyst
  - Already in place and proven
- DPF Not Needed
  - Gas is cleanest hydrocarbon
- Energy Bill
- Highway Bill

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# Comparison of Natural Gas vs. Diesel

## Key Characteristics

	L 10 G	C 8.3	C/L Gas Plus	ISL G
Emissions	Better	Better	Better	Better
Reliability	Worse	Worse	Similar	Similar
Fuel Cost/Mile	Worse	Worse	Similar	Better
Durability	Worse	Worse	Similar	Similar
LCC	Worse	Worse	Similar	Better
Timeline	1989	1996	2005	2007

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# **Key Economic Drivers**

1. Six fold increase in reliability/durability since 2001
2. CNG is closing maintenance cost gap
  - Basic service intervals same as diesel
  - Spark ignition does result in higher scheduled maintenance costs
3. Fuel cost savings is overwhelming
  - CNG/LNG fixed term contract versus diesel based on \$60 bbl crude oil.
  - Fuel economy gap closing.

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# Key Assumptions

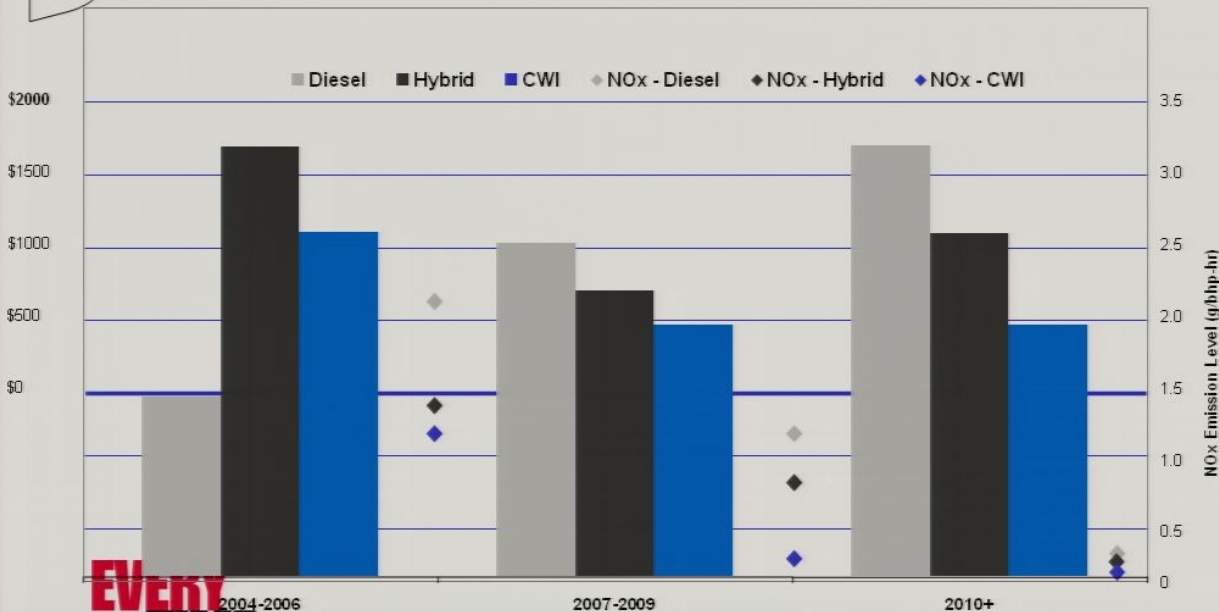
- Assumes 25% CNG/Diesel base fuel cost differential
- Hybrid fuel economy based on GM/Allison promotional material
- Hybrid continuous technology improvement assumed - both capital and battery life
- Assumes US transit funded at 83% of initial capital cost (Huge benefit to hybrid LCC)
- Model assumes diesel penalties for EGR and exhaust aftertreatment
- Assumes planned gains in efficiency with 2007 CNG technology, and includes all capital and operating costs related to infrastructure requirements

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# DRAFT



## Annual Incremental Capital and Operating Costs - Urban Bus



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CNG declining LCC - efficiency gains and no complex after treatment costs

CNG is now and will continue to be the emissions leader



## **Summary of results**

- 2010 technology natural gas and diesel fueled vehicles are cost competitive with each other over initial owner lifetimes
- Vehicle technology costs for 2010 emissions level diesel vehicles have less price advantage over natural gas vehicles than they do today
- Other than some extreme price scenarios, modeled future costs don't show clear cost preference for one fuel choice over the other in the vehicle applications studied
- The results represent a significant finding, considering the prices advantage of diesel over natural gas in meeting 2004 standards.



# Highway Bill - Transit and Municipal Fleets



Old Tax	New Tax Oct 1, 2006	Tax Credit Oct 1, 2006
---------	------------------------	---------------------------

## Own Infrastructure

CNG\$ / DGE

0

0

0.55

To Fleet

## Don't Own Infrastructure

CNG\$ / DGE

0

0

0.55

To Fuel  
Provider

## All Infrastructure

LNG \$ / DGE

0

0

0.85

To Fuel  
Provider

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# Highway Bill - Private Fleets

Old Tax

New Tax  
Oct 1, 2006

Credit

Net Tax Credit  
Oct 1, 2006

Own Infrastructure

CNG\$ / DGE

0.067

0.203

0.55

0.352

To Fleet

Don't Own Infrastructure

CNG\$ / DGE

0.067

0.203

0.55

0.352

To Fuel  
Provider

All Infrastructure

LNG\$ / DGE

0.202

0.413

0.85

0.437

To Fuel  
Provider

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# Energy Bill



Transit and Municipal Fleets - 49 States	Max. \$32,000 Income Tax Credit to OEM with Provision that Credit has been Applied to End User Cost
Refuse (Private Fleets)	Max \$32,000 Income Tax Credit to Purchaser
Hybrid	Maximum \$12,000 Credit to OEM with Provision that Credit has been Applied to End User Cost
Infrastructure	Max \$30,000 Income Tax Credit

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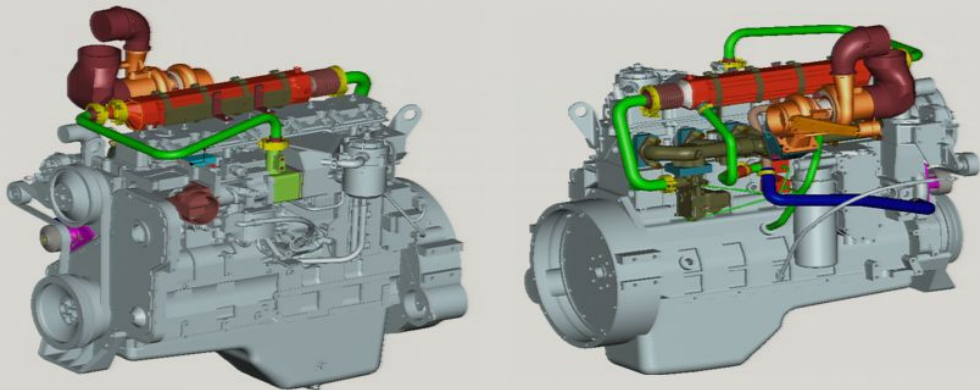
# Conclusions

- Energy & Highway Bills will provide a significant LCC benefit for NG vehicles
  - Highway Bill fuel tax credit is more significant than the Energy Bill provisions
- Energy Bill (income tax credit based on incremental vehicle purchase price) is less significant for Urban Bus than for Refuse, due to existing FTA funding for Urban Bus fleets
- Diesel Electric Hybrids do not qualify for fuel tax credits under the Highway Bill
- Highway Bill in particular is expected to create LCC differentiation for Natural Gas vs. Diesel & Diesel Electric Hybrid

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# Next Generation Technology

## Cooled EGR



- Lower emissions with use of simple passive TWC
- Higher efficiency with combustion enhancements

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## Engine Product Line-up



### Advanced Lean Burn Spark Ignition

<i>B Gas Plus</i>	1.8 NOx+NMHC /0.01 PM
<i>BLPG Plus</i>	2.2 NOx+NMHC /0.01 PM
<i>C Gas Plus</i>	1.8 NOx+NMHC /0.01 PM
<i>L Gas Plus</i>	1.4 NOx+NMHC /0.01 PM
<i>B Gas International</i>	Euro 3

In Production

← 2005 Availability

*B Gas Plus*(HCNG) 0.9 NOx+NMHC/0.01 PM

← In Demonstration

2007 CWI

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At 2010 PM Targets Today

**Demonstrated 0.2 NOx**

Lower LCC

Improve Fuel efficiency

Technology  
Evaluation  
Criteria

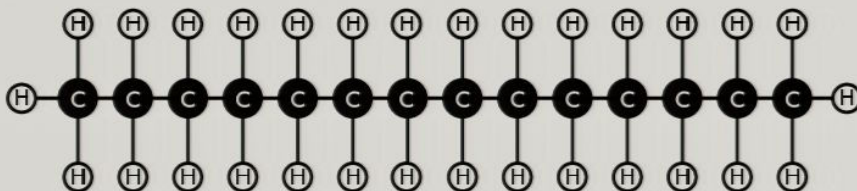
# Environment



## Simpler Cleaner Fuel

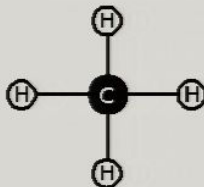
### Diesel $C_{14} H_{30}$

Complex Hydro Carbon



### Methane $CH_4$

Simplest Hydro Carbon



Highest hydrogen-to-carbon ratio of any hydrocarbon

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**Westport**

# **EVERY ALTERNATIVE.**

## **A Win-Win Solution**

**Environment**

**Energy Security**

**Financial**